Fundamental Mechanics: Class Exam II

8 October 2014

Name: _____ **Total:** /70

Instructions

- There are 7 questions on 5 pages.
- Show your reasoning and calculations and always justify your answers.

Physical constants and useful formulae

$g = 9.80\,\mathrm{m/s}$

Question 1

A phone with mass 0.25 kg hangs from a rope in an elevator. The elevator is initially at rest. It then moves upwards and the rope exerts a constant upward force of 3.0 N on the phone. Determine how much time it takes for the phone to reach a speed of 2.0 m/s.

$m = 0.25\ kg$
$T = 3.0\ N$
$g = 9.8\ m/s$

moving UP $\Sigma F = ma$

$\Sigma F_y = ma_y$

$T - mg = ma_y$

$3.0N - 0.25\,kg(9.8\,m/s) = 0.25\,kg(a_y)$

$3.0N - 2.45N = 0.25\,kg\,a$

$0.55N = 0.25\,kg\,a$

$a = 2.2\,m/s^2$

$t_0 = 0s$ $\quad t = 0.91s$

$x_0 = 0m$ $\quad x_1 =$

$v_{0y} = 0\,m/s$ $\quad v_{1y} = 2.0\,m/s$

$a = 2.2\,m/s^2$

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$v_{1x} = v_{0x} + a_x \Delta t$

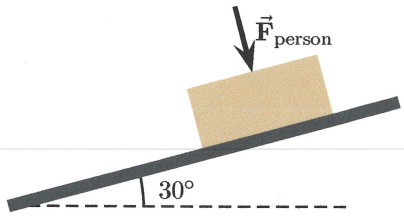
$2.0\,m/s = 0\,m/s + 2.2\,\Delta t$

$\Delta t = 0.91s$

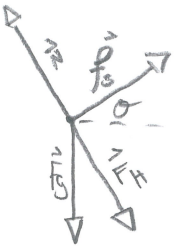
$\Delta t = 0.91s$

Question 2

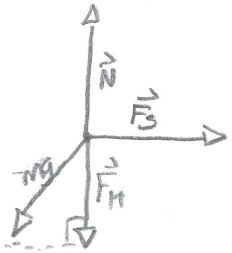
A 50 kg box is on an inclined ramp. The coefficient of kinetic friction between the block and ramp is 0.30 and the coefficient of static friction is 0.40. A person pushes perpendicular to the surface and the block stays at rest; without this force the block would slip down the ramp. Determine the minimum force that the person must exert to keep the block at rest.



$\Sigma F = 0$ since box is at rest



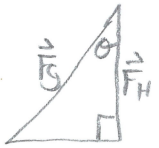
$\theta = 30$



$\Sigma_x = 0$

$\Sigma_y = 0$

Force	x	y
$\vec{N}$	0	612.5 N
$\vec{F}_H$	0	$-\vec{F}_H$
$\vec{F}_S$	$\vec{F}_S$	0
$\vec{F}_G$	$-mg\sin\theta$	$-mg\cos\theta$



$\theta = 30^\circ$

x comp

$-mg\sin\theta$

y comp

$-mg\cos\theta$

$\mu_s = 0.40$

$m = 50\,kg$ $g = 9.8\ m/s^2$

$\theta = 30^\circ$

$\Sigma_x = 0$: $\vec{F}_S - mg\sin\theta = 0$: $\mu_s \vec{N} = mg\sin\theta$

$0.40(\vec{N}) = 50\,kg\,(9.8\ m/s^2)\sin 30$ $\vec{N} = 612.5\ N$

$\vec{N} = \frac{245\ N}{0.40} = 612.5$

$\Sigma_y = 0$: $\vec{N} - \vec{F}_H - mg\cos\theta = 0$: $-F_H = mg\cos\theta - \vec{N}$

$F_H = \vec{N} - mg\cos\theta$

$F_H = 612.5\ N - 50\,kg\,(9.8\ m/s^2)\cos 30$

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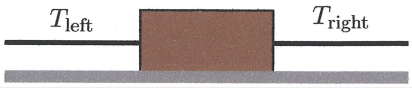
$F_H = 188.18\ N$

Question 3

A box moves with a constant speed to the right along a horizontal frictionless surface. While this occurs, two ropes pull horizontally on the box from either side. Which of the following (choose one) is correct?



(i) The tension in the right rope must equal that in the left.
ii) The tension in the right rope must be larger than in the left.
iii) The tension in the left rope must be larger than in the right.

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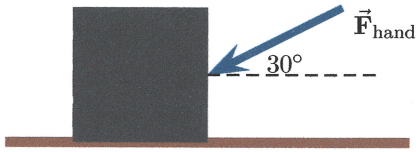
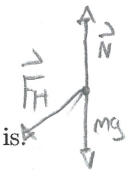
Question 4

A person pushes down with a force of magnitude F_{hand} on a block of mass m at an angle of 30° above the horizontal. Which of the following (choose one) is true regarding the normal force, n, exerted by the surface on the block?



i) $n < mg$
(ii) $n > mg$
iii) $n = mg$
iv) Whether n is larger than mg depends on how much friction there is.



$\Sigma F_y = 0$
$\vec{N} - \vec{F}_H - mg = 0$
$\vec{N} = \vec{F}_H + mg$

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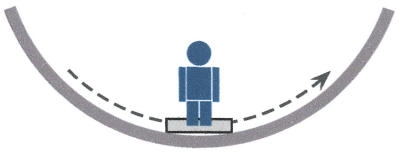
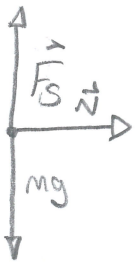
Question 5

A person on a sled slides along a curved track where the track walls are vertical. Viewed *from above* the person and sled follow the indicated path at speed 40 m/s. The mass of the skateboarder is 70 kg and the distance from him to the center of the curve is 5.0 m. Determine the normal force exerted on the person.





In circular motion

$V = 40$ m/s
$m = 70$ kg
$R = 5.0$ m

$\Sigma F_x = ma_x$

$a = v^2/r$

$a = \frac{(40\text{m/s})^2}{5.0\text{m}}$

$\Sigma F_x : \vec{N} = ma_x$

$\vec{N} = 70\text{kg}\left(\frac{(40\text{m/s})^2}{5.0\text{m}}\right)$

$\vec{N} = 22{,}400\text{N}$

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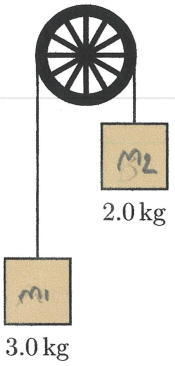
Question 6

Two blocks are connected by a massless string that runs over a massless pulley. Ignore air resistance.



a) Determine the acceleration of the block on the right.

$\sum F_y = ma_y$

(A) $\sum_y = ma_y$ $\quad m_1 = 3.0\,kg$

$\vec{T}_1 - mg = m_1 a_y$

$\vec{T}_1 = m_1 g - m_1 a_y$

(B) $\sum_y = ma_y$ $\quad m_2 = 2.0\,kg$

$\vec{T}_2 - m_2 g = -m_2 a_y$

$\vec{T}_2 = m_2 g + m_2 a_y$

$T_1 = T_2$ since masless string and masless pulley

$\vec{T}_1 - m_1 g = -m_1 a_y$

$m_2 g + m_2 a_y - m_1 g = -m_1 a_y$

$m_2 g - m_1 g = -m_2 a_y - m_1 a_y$

$g(m_2 - m_1) = a_y(-m_2 - m_1)$

$a_y = \dfrac{g(m_2 - m_1)}{(-m_2 - m_1)}$

$a_y = \dfrac{9.8\,m/s^2(+2.0\,kg - 3.0\,kg)}{(-2.0\,kg - 3.0\,kg)}$

$a_y = 1.96\,m/s^2$

$a = 1.96\,m/s^2$

Question 6 continued ...

b) Suppose that the block on the right is held at rest. A hand gives it a brief tug down. After it leaves the hand the right block moves down for a while, then reverses direction and moves up. Which of the following (choose one) is true *after it leaves the hand*? Ignore air resistance and friction.

(i) The acceleration of the block on the right is the same whether it moves up or down.

ii) The acceleration of the block on the right is larger while it moves up than while it moves down.

iii) The acceleration of the block on the right is smaller while it moves up than while it moves down.

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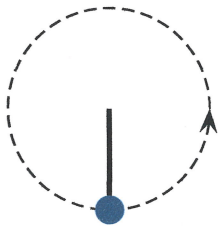
Question 7

A ball of mass m swings at the end of a string in a vertical circle. Which of the following (choose one) is true regarding the tension, T, in the string when the ball is at the *lowest point* in the circle?



i) $T = mg$ in all cases.

(ii) $T > mg$ in all cases.

iii) $T < mg$ in all cases.

iv) $T > mg$ when the speed is large enough and $T < mg$ when the speed is small enough.

Explain your choice briefly.

Tension has to be greater than gravity otherwise if it were equal it would remain at rest and if it were less it would fall.

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